PATENT SPECIFICATION (11) 1389881

(21) Application No. 39635/72 (22) Filed 25 Aug. 1972
(31) Convention Application No. 175457 (32) Filed 27 Aug. 1971 in
(33) United States of America (US)
(44) Complete Specification published 9 April 1975
(51) INT CL² C03B 5/26 5/22
(52) Index at acceptance
C1M 11A2 11T

1389881

(54) METHOD AND APPARATUS FOR REFINING MOLTEN GLASS

(71) We, OWENS-ILLINOIS, INC., a corporation organised and existing under the laws of the State of Ohio, United States of America, of Toledo, State of Ohio, United States of America, (assignee of RAYMOND SEARS RICHARDS and DOUGLAS FRANCIS ST. JOHN), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for refining molten glass.

U.S. Patent Specification No. 2,006,947 discloses a method and apparatus for refining molten glass by rotating a mass of glass in a container to subject the glass to forces greater than gravity to remove entrapped gaseous inclusions. The refining molten glass is then discharged through a tube extending through a refractory cone positioned in the bottom of the apparatus. However, this known apparatus provides a very low discharge rate in tons of refined glass per day.

In accordance with one aspect of the present invention there is provided a method of refining molten glass comprising the steps of feeding unrefined molten glass into one end of a rotating container, discharging the molten glass from the other end of the rotating container, and depositing the discharged molten glass onto a fixed surface, wherein the molten glass is discharged from the container in a direction counter to the direction of rotation of the container to retard the average angular velocity of the discharged glass so that the average angular velocity of the discharged glass relative to the fixed surface is approximately zero.

In accordance with a further aspect of the present invention there is provided apparatus for refining molten glass comprising a rotatable container having a glass-containing chamber disposed within a shell, at least one discharge tube piercing the chamber and the shell, said discharge tube being curved or angled so that adjacent its free end its axis is in a direction counter to the direction of rotation of the container, and a stationary container positioned relative to the discharge tube for collecting molten glass discharged from the container through the discharge tube, wherein the discharge tube is so dimensioned that molten glass is discharged through the free end thereof at an angular velocity approximately equal and opposite the angular velocity of the rotatable container with respect to the stationary container.

Gaseous inclusions can be formed within refined molten glass as a result of "shear" action. Shear is the term applied to the result of discrete areas of molten glass in conflict, due to their motion. Also, when discrete areas of glass are in turbulent motion, air can be entrapped, resulting in gaseous inclusions. The apparatus and method of the invention enable transfer of the glass from the rotating container to the inner surface of a collecting, stationary container at an average relative velocity of "zero", or near "zero", and a stream of molten glass is laid down with little "shear" and the possibility of bubble entrapment is reduced. Preferably, relationships among glass-layer thickness, tube discharge length, tube diameter, angular velocity, and glass viscosity, are all controlled so that the average angular velocity of the glass relative to the average angular velocity of the stationary container is equal to or about "zero".

The invention will now be described further by way of example with reference to the accompanying drawings, in which:—

Fig. 1 is a side view, with certain elements broken away, of apparatus of this invention;

Fig. 2 is a cross-section of the apparatus of Fig. 1, taken along line 2—2, and

Fig. 3 is a cross section of the apparatus of Fig. 1, taken along line 3—3.

The Applicants' copending patent application No. 1,360,916 (15265/72), filed April 4, 1972, discloses a method and apparatus for removing entrapped gaseous inclusions.

The apparatus disclosed in that application removes entrapped gaseous inclusions from the molten glass by rotating a contained mass of glass at a sufficient number of revolutions per minute to subject the glass to forces greater than gravity; the induced force drives entrapped gaseous inclusions out into the atmosphere. The molten glass is collected in a pool and is discharged through a tube positioned in the bottom of the container along its axis of rotation of the container, and the peripheral velocity of the glass is low.

In the apparatus of this invention, the molten glass is discharged from areas in the container having a high peripheral velocity; up to 500 feet per second.

Referring to the drawings, the apparatus of this invention comprises a stationary container 10 and a rotatable container 11. The stationary container is positioned relative to the rotatable container to receive discharbed glass from at least one discharge tube 16 through opening 17. In the embodiment illustrated two discharge tubes 16 are provided.

Rotatable container 11 is mounted on a support mechanism 21; the support provides for rotation and is not described herein; any number of support structures are contemplated; the rotatable containers are usually mounted vertically or nearly vertically and usually about the central vertical axis.

Rotatable container 11 is constructed to contain a mass of molten glass, while rotating at a high angular velocity.

Rotatable container 11 is constructed with a shell 13, layers of insulating material 14 positioned within the wall, and chamber 15, which is the container for molten glass.

Discharge tubes 16 pierce the wall of the chamber 15, insulating layers 14, and container wall 13. The tubes 16 are curved or angled in a direction counter to the intended direction of rotation. The outlets 17 of the tubes 16 are preferably symmetrically arranged around the outer periphery of the rotatable container 11. Outlets 17 are positioned relatively close to the inner surface of stationary container 10. The tubes 16 are preferably tapered with the smaller diameter being the outlet end 17. The tubes 16 may be curved with a uniform radius as is shown in Fig. 3, or may be angular. The curved shape illustrated is preferred for smooth glass flow. The arrow on Fig. 3 indicates the direction of rotation of the container 11.

Chamber 15 is made of a refractory material or a metal such as platinum, or any other material capable of holding glass at molten temperatures without serious deterioration.

Guide wheels 23 are positioned about the periphery of the outer wall of the rotatable container to provide stability during rotation.

Belt 22 connects the container to motor 19 and rotates the container. Other rotation means may be employed, the means selected being a matter of convenience and practicality.

A spreader plate 18 is positioned within the container 11 relatively close to the inlet opening for the molten stream and partially fills this inlet opening. The spreader plate 18 is received in an annular groove in the wall of chamber 15 and in the insulating material 14. The spreader plate 18 is pierced with a plurality of openings 20 to permit the glass to flow down the chamber walls.

The entering glass stream is distributed by spreader plate 18, forms a relatively thin film "G" about the inner surface of the chamber 15 having thickness "T". Entrapped gaseous inclusions are driven to the surface of the glass and into the surrounding atmosphere; hence, entrapped gaseous inclusions in the molten glass are greatly reduced in both number and size.

Following are typical operating examples of this invention, wherein:

R_3 is a radius from the center axis to the inner surface of the stationary container, R_2 is the radius from the center axis to the outer surface of the discharge tube 16, and R_1 is the radius measured to the inner surface of the glass, having exaggerated thickness "T" as shown in Figs. 1 and 3.

	EXAMPLE I	EXAMPLE II
R_3	=.50 ft.	1 ft.
R_2	=.49 ft.	.98 ft.
R_1	=.2 ft.	.3 ft.
Viscosity	=50 Poises	100 Poises
Rotation (RPM)	=3,000 RPM	2,000 RPM
Throughput (Tons/Hour)	=3.55 Tons/hour	13.5 Tons/hour
Tube Diameter "D"	=1/8 inch	7/32 inch

Entrapped gaseous inclusions in molten glass are objectionable because they result in defects in the hardened glass. The entrapped inclusions can be removed from molten glass by subjecting the glass to forces greater than gravity and causing the entrapped inclusions to leave the glass and go into the surrounding atmosphere as is described more fully in the copending application referred to hereinabove. The method of the invention reduces the gaseous inclusion content of the molten glass and then enables

discharge of the refined glass from a rotating glass mass without reintroducing gaseous inclusions.

Referring to Fig. 1, unrefined molten glass enters the rotating container, as indicated by the arrow in Figure 1; the stream is diverted to the inner surface of the container walls and is subjected to forces greater than gravity. Gaseous inclusions are removed from the molten glass and are expelled into the atmosphere surrounding the glass surface.

A portion of the mass of refined molten glass is withdrawn from the rotating mass through one or more curved or angled discharge tubes. The discharge path of the glass is in a direction counter to the direction of rotation of the mass; the average velocity of the exiting glass is retarded so that the discharged molten glass is deposited on an adjacent stationary surface at a near 'zero' average velocity, relative to that surface. Gaseous inclusions are not reintroduced into the deposited glass. Retarding the average velocity of the removed or discharged molten glass may be accomplished by controlling the direction of the discharged stream, the distance that discharged glass travels from the revolving molten mass to the tube outlet, the viscosity of the discharged glass, the speed of rotation of the container, and the dimensions of the rotating and stationary containers.

WHAT WE CLAIM IS:—

1. A method of refining molten glass comprising the steps of feeding unrefined molten glass into one end of a rotating container, discharging the molten glass from the other end of the rotating container, and depositing the discharged molten glass onto a fixed surface, wherein the molten glass is discharged from the container in a direction counter to the direction of rotation of the container to retard the average angular velocity of the discharged glass so that the average angular velocity of the discharged glass relative to the fixed surface is approximately zero.

2. A method as claimed in claim 1, wherein the container is rotated about a vertically extending axis, and the unrefined molten glass is fed into the top of the container and the molten glass is discharged from the bottom of the container.

3. Apparatus for refining molten glass comprising a rotatable container having a glass-containing chamber within a shell, at least one discharge tube piercing the chamber and the shell, said discharge tube being curved or angled so that adjacent its free end its axis is in a direction counter to the direction of rotation of the container, and a stationary container positioned relative to the discharge tube for collecting molten glass discharged from the container through the discharge tube, wherein the discharge tube is so dimensioned that molten glass is discharged through the free end thereof at an angular velocity approximately equal and opposite to the angular velocity of the rotatable container with respect to the stationary container.

4. Apparatus as claimed in claim 3, wherein the rotatable container is cylindrical and is rotatable about its vertically extending axis, the glass-containing chamber having an inlet opening in its top end and the discharge tube or tubes extending from the bottom of the glass-containing chamber.

5. Apparatus as claimed in claim 3 or 4 having a plurality of discharge tubes, the free ends of said discharge tubes being symmetrically arranged around the outer periphery of the rotatable container.

6. A method of refining molten glass substantially as herein described with reference to and as illustrated in the accompanying drawings.

7. Apparatus for refining molten glass substantially as herein described with reference to and as illustrated in the accompanying drawings.

W. P. THOMPSON & CO.,
Coopers Buildings,
Church Street,
Liverpool, L1 3AB.
Chartered Patent Agents.

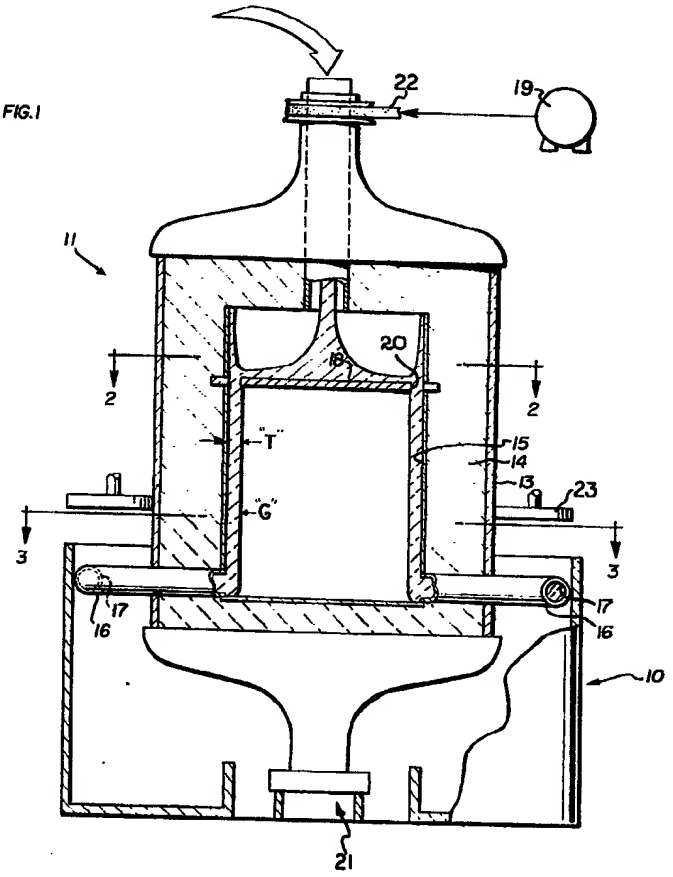
Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1975.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1389881 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1



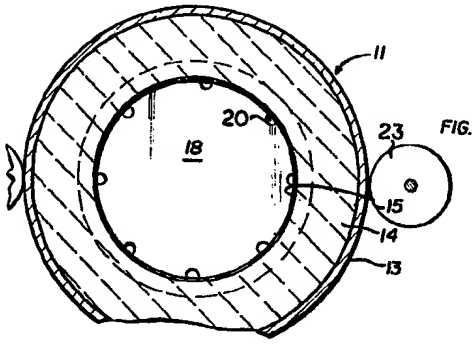


FIG. 2

1389881 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

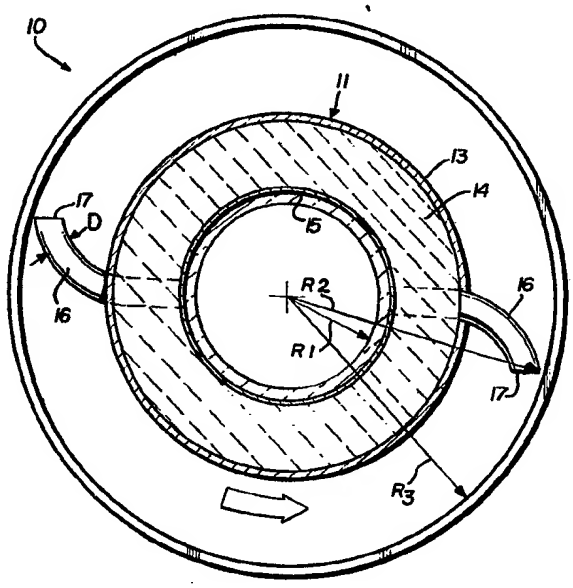


FIG. 3